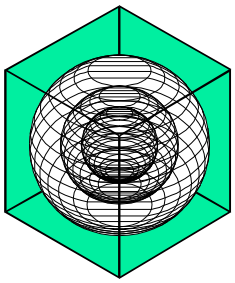

Energy Systems Laboratory
Texas A&M University

Baseline Energy Usage Modeling and Continuous Commissioning[SM] Energy Savings for the Matheson Courthouse Building in Salt Lake City, Utah

By

Yiwen Zhu
Juan-Carlos Baltazar
David Claridge

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Introduction

During January 2002, personnel from the Energy Systems Laboratory at Texas A&M University (ESL) began implementing Continuous Commissioning^{SM} (*CC*^{SM}) [1] measures in the Matheson Courthouse Building in Salt Lake City, Utah. The objective of this report is to present the energy consumption baseline model(s) for the building and evaluate the energy savings that occurred due to the *CC* process.

Data Sources

The data for whole building electricity and gas usage came from utility monthly bills. The daily maximum and daily average outside air temperatures in Salt Lake City were retrieved from http://www.ncdc.noaa.gov/oa/pdfs/lcd.html. Monthly maximum and average temperatures were calculated for the periods covered by the bills.

Figure 1 shows the monthly time series plots of whole building gas consumption (Wbheat) and the corresponding outside temperatures. The monthly whole building electricity consumption (Wbele) and peak demand are shown in Figure 2. The monthly maximum and average outside temperature data for the same period are shown in Figure 3.

Modeling

As *CC* implementation was started in January 2002, one-year data sets before this date were tested for use as baseline data for the building energy performance. The monthly energy consumption data was converted to daily average consumption to correct for the length of different billing periods and baseline models for each kind of energy use as a function of the ambient temperature were developed. Typically the previous 12 months before any commissioning activity is carried out in the facility are used as the baseline period to determine energy savings. However, the data sets for this period had a great deal of scatter and the reliability of the models created from this data was low. Consequently, earlier data was used to create the baseline models to obtain better and more reliable models. This process led to selection of data from August 2000 through July 2001 for the electricity and gas usage baseline models, while the best period for the electric peak demand baseline model was April 2000 through March 2001.

[1] Continuous Commissioning and CC are service marks of the Energy Systems Laboratory.

The baseline models created for electricity consumption, demand and gas usage are shown in Figure 4, Figure 5 and Figure 6 respectively, and a summary of the statistical parameters of these models is listed in Table 1.

Energy Savings Evaluation

Energy and cost savings were evaluated beginning with January 2002 corresponding to the period when CC implementation began. The energy cost for electricity is $0.027737 /kWh, and demand charge is $8.10 /kW. Since the prices for gas varied month by month, a weighted average cost for gas of $4.588 /MMBtu in 2002 was used. Table 2, Table 3 and Table 4 show respectively the electricity consumption savings, demand savings and gas consumption savings for the Matheson Courthouse Building in 2002.

Conclusions

Savings from the CC measures implemented in the Matheson Courthouse Building in Salt Lake City, UT during 2002 have been evaluated for calendar year 2002. The electricity consumption savings during this year were 17.39% ($28,315), while the average reduction in electric demand was 1.29% ($1,636). The gas use savings were 37.40% ($44,972.48). Because these savings were obtained during the implementation period, it is expected that the savings for 2003 will be larger.

These savings were determined as the difference between the measured consumption in 2002 and baseline models of monthly consumption developed for the Matheson Courthouse Building from one-year of measured data before 2002.

Table 1. Original and selected electricity consumption, electric peak demand and gas usage baseline model for the Matheson Courthouse Building

	MODELING												
ENERGY	START	END	UNITS	MOD	Ycp/Y_{mean}	LS	RS	Xcp	RMSE	CV-RMSE	R2	adjR2	Comments
wbele	Jan-01	Dec-01	kWh/day	3P	13037.89	0.0000	111.7579	36.0834	1800.31	0.1	0.5427	0.4970	
wbele	Aug-00	Jul-01	kWh/day	3P	13601.29	0.0000	184.3381	41.8975	380.56	0.0	0.9838	0.9822	selected model
Wbheat	Jan-01	Dec-01	MMBtu/day	3P	29.46	-2.0811	0.0000	66.8793	14.42	0.2	0.8469	0.8316	
Wbheat	Aug-00	Jul-01	MMBtu/day	3P	41.49	-2.7074	0.0000	57.7321	9.36	0.1	0.9319	0.9251	selected model
demand	Jan-01	Dec-01	kW	3P	1003.83	0.0000	7.2646	27.5352	285.01	0.2	0.2043	0.1248	
demand	Apr-00	Mar-01	kW	3P	878.57	0.0000	20.4037	31.9777	91.56	0.1	0.9489	0.9433	no data for 6/00 (selected model)

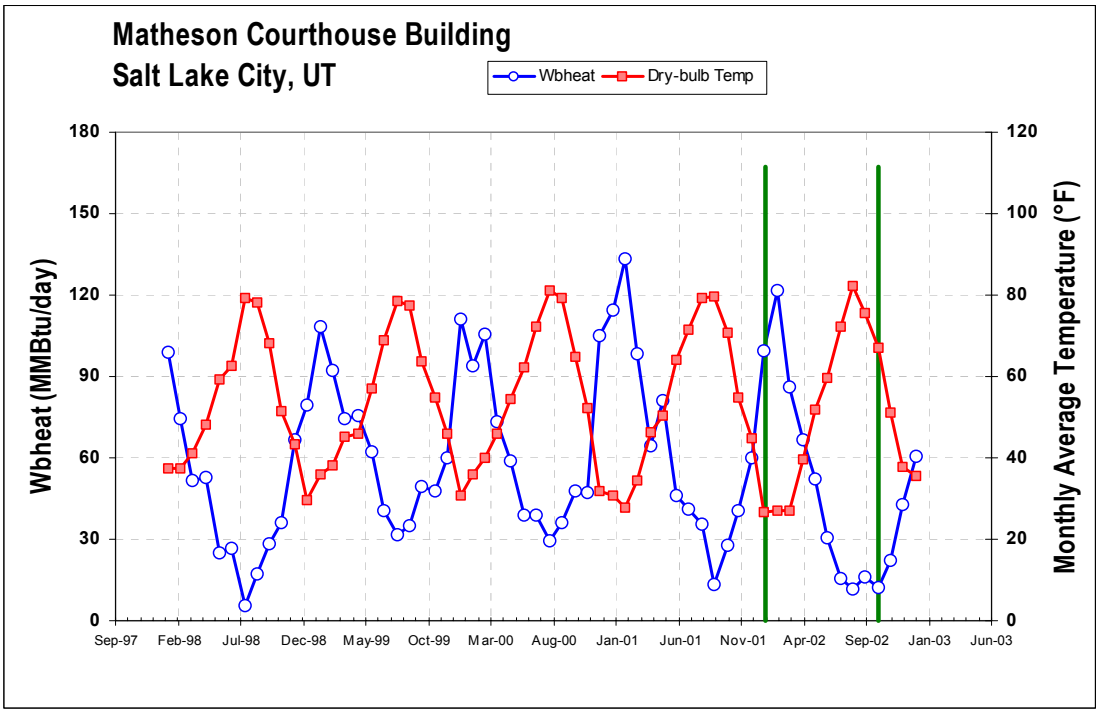


Figure 1. Monthly average gas usage and outdoor temperatures time series of the Matheson Courthouse Building.

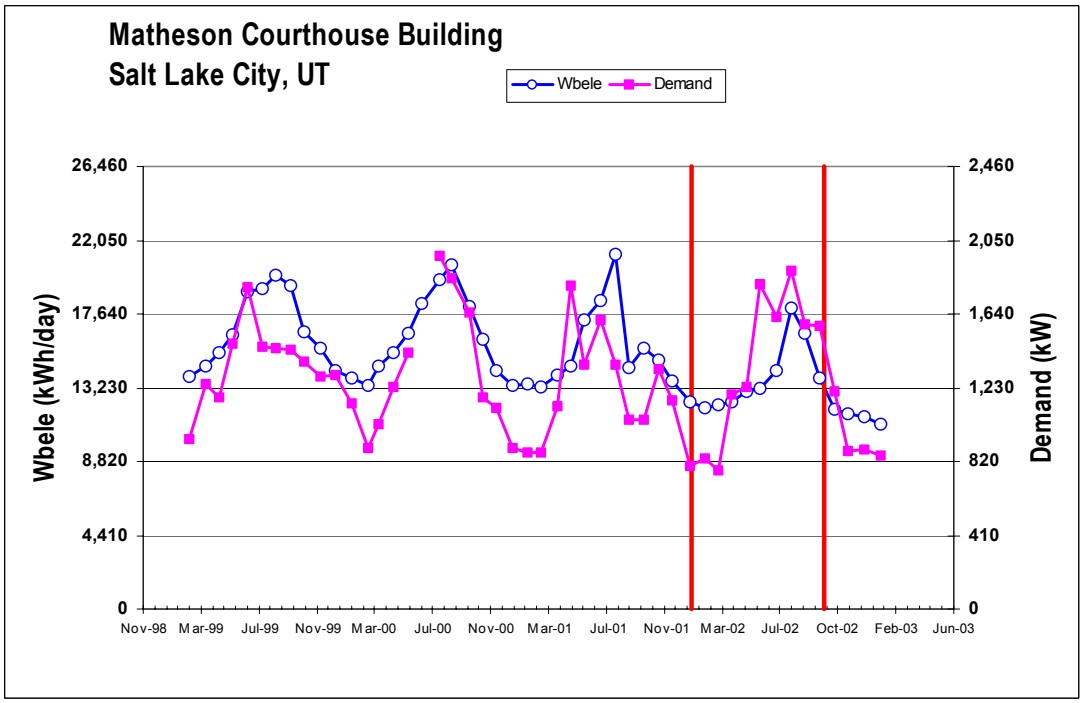


Figure 2. Monthly average electricity consumption and peak demand time series of the Matheson Courthouse Building

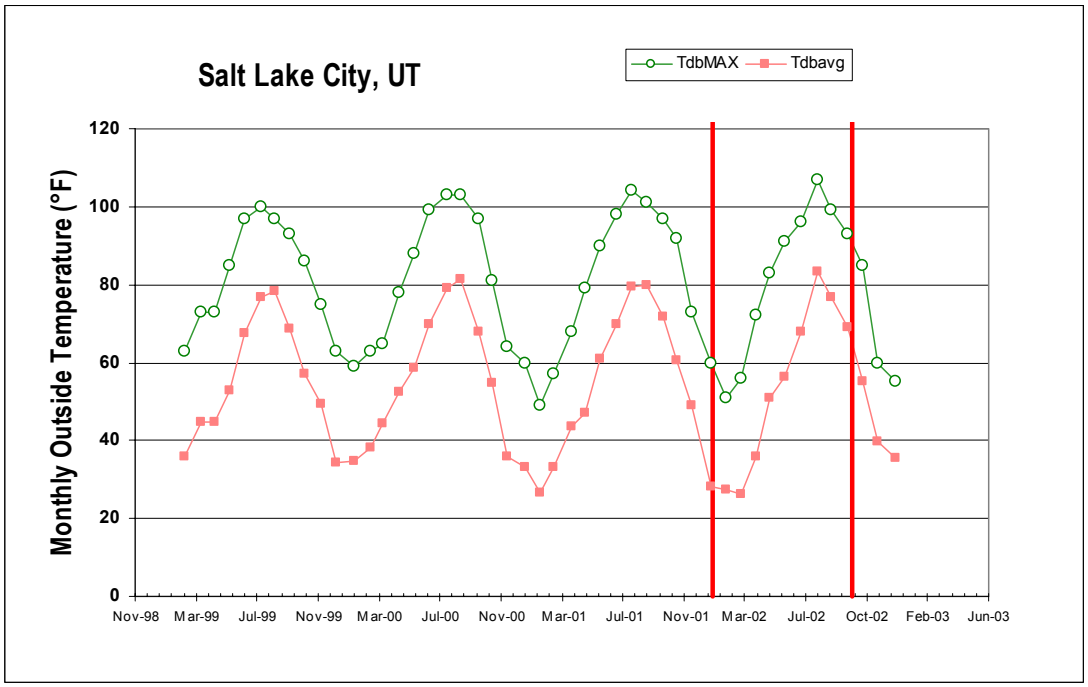


Figure 3. Monthly maximum and average outside temperatures time series at Salt Lake City, UT.

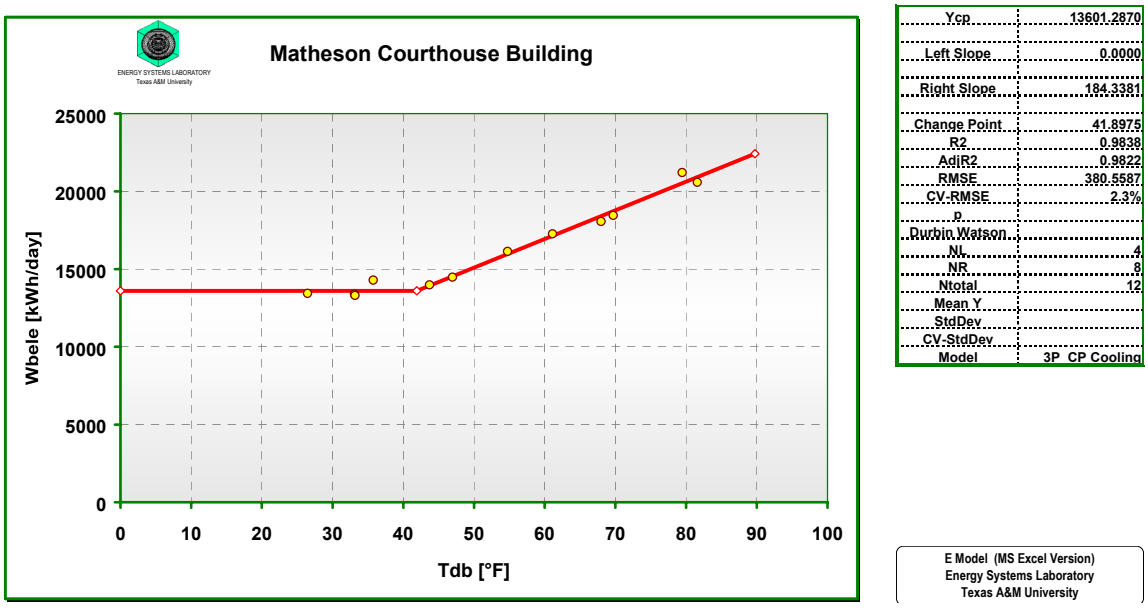


Figure 4. Whole building electricity consumption baseline model for the Matheson Courthouse Building obtained from the period of 8/00 - 7/01

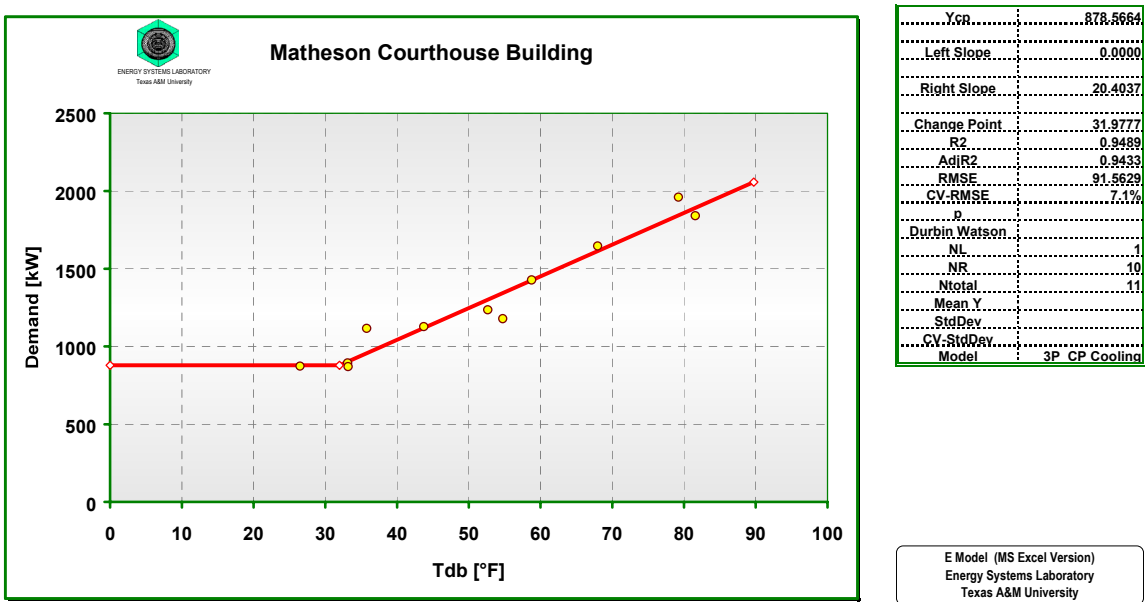


Figure 5. Electric demand baseline model for the Matheson Courthouse Building obtained from the period of 4/00 - 3/01.

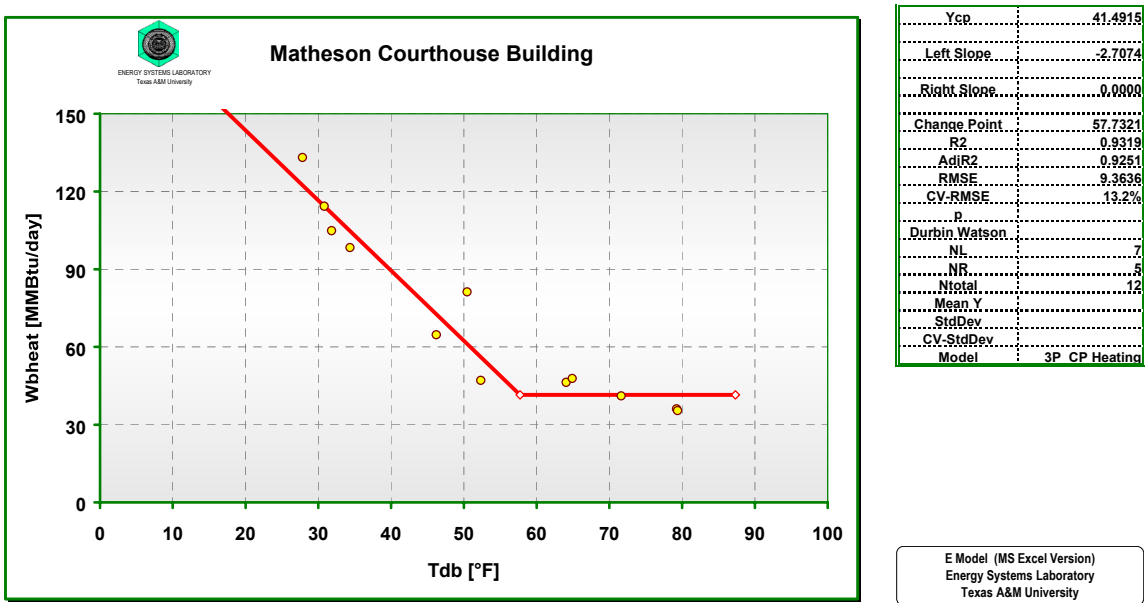
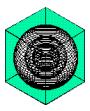


Figure 6. Whole building gas usage baseline model for the Matheson Courthouse Building obtained from the period of 8/00 - 7/01.

Table 2. Whole building electricity consumption savings for the Matheson Courthouse Building in the year 2002



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Matheson Courthouse Building

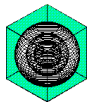
Modeling Period: 8/00 ~ 7/01 — ELECTRICITY

(1)		(2)	
Ycp=	13601.2870	Ycp=	
LS=	0.0000	LS=	
RS=	184.3381	RS=	
Xcp=	41.8975	Xcp=	
RMSE=	380.5587	RMSE=	
CV-RMSE=	2.30	CV-RMSE=	
R2=	0.9838	R2=	
AdJR2=	0.9822	AdJR2=	

Matheson Courthouse Building

					Measured	Predicted	Savings		PRICE $/kWh $0.0277
Month No.	Day	Year	Days/Mo	Tdb °F	Total Cons kWh	Total Cons kWh	kWh	%	USD
12	28	2001							
1	28	2002	31	27.6	372,000	421,640	49,640	11.77%	$1,376.86
2	25	2002	28	26.3	342,900	380,836	37,936	9.96%	$1,052.23
3	26	2002	29	36.0	357,900	394,437	36,537	9.26%	$1,013.44
4	24	2002	29	51.0	376,800	442,913	66,113	14.93%	$1,833.78
5	23	2002	29	56.4	381,900	472,039	90,139	19.10%	$2,500.17
6	24	2002	32	67.8	455,100	588,109	133,009	22.62%	$3,689.27
7	25	2002	31	83.3	558,300	658,363	100,063	15.20%	$2,775.44
8	23	2002	29	76.7	477,000	580,429	103,429	17.82%	$2,868.82
9	24	2002	32	69.2	442,500	596,220	153,720	25.78%	$4,263.73
10	23	2002	29	55.2	347,400	465,771	118,371	25.41%	$3,283.26
11	22	2002	30	39.9	349,200	408,039	58,839	14.42%	$1,632.01
12	26	2002	34	35.5	389,400	462,444	73,044	15.80%	$2,026.01
					4,850,400	**5,871,240**	**1,020,840**	**17.39%**	**$28,315.03**

Table 3 Electric demand savings for the Matheson Courthouse Building in the year 2002



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Matheson Courthouse Building

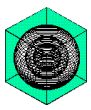
Modeling Period: 4/00 ~ 3/01 DEMAND

(1)		(2)
Ycp=	878.5664	Ycp=
LS=	0	LS=
RS=	20.4037	RS=
Xcp=	31.9777	Xcp=
RMSE=	91.5629	RMSE=
CV-RMSE=	7.10	CV-RMSE=
R2=	0.9489	R2=
AdJR2=	0.9433	AdJR2=

Matheson Courthouse Building

					Measured	Predicted	Savings		PRICE $ /kW $8.1000
Month No.	Day	Year	Days/Mo	Tdb °F	Demand kW	Demand kW	kW	%	USD
12	28	2001							
1	28	2002	31	27.6	839	879	40	4.50%	$320.49
2	25	2002	28	26.3	768	879	111	12.58%	$895.59
3	26	2002	29	36.0	1,191	961	(230)	-23.89%	($1,860.25)
4	24	2002	29	51.0	1,232	1,266	34	2.68%	$275.30
5	23	2002	29	56.4	1,805	1,377	(428)	-31.07%	($3,465.56)
6	24	2002	32	67.8	1,623	1,610	(13)	-0.82%	($107.50)
7	25	2002	31	83.3	1,879	1,926	47	2.45%	$382.25
8	23	2002	29	76.7	1,583	1,791	208	11.61%	$1,683.63
9	24	2002	32	69.2	1,571	1,638	67	4.08%	$540.95
10	23	2002	29	55.2	1,210	1,353	143	10.58%	$1,160.18
11	22	2002	30	39.9	881	1,040	159	15.25%	$1,284.10
12	26	2002	34	35.5	886	951	65	6.84%	$526.78
					15,468	**15,670**	**202**	**1.29%**	**$1,635.96**

Table 4 Whole building gas usage savings for the Matheson Courthouse Building in 2002



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Matheson Courthouse Building

Modeling Period: 8/00--7/01 Wbheat

(1)		
Ycp=	41.4915	Ycp=
LS=	-2.7074	LS=
RS=	0.0000	RS=
Xcp=	57.7321	Xcp=
RMSE=	9.3636	RMSE=
CV-RMSE=	13.2000	CV-RMSE=
R2=	0.9319	R2=
AdJR2=	0.9251	AdJR2=

Matheson Courthouse Building

					Measured	Predicted	Savings		PRICE $/MMBtu $4.5880
Month No.	Day	Year	Days/Mo	Tdb °F	Total Cons MMBtu	Total Cons MMBtu	MMBtu	%	USD
12	31	2001							
1	30	2002	30	27.2	3,647	3,727	81	2.17%	$370.85
3	1	2002	30	27.0	2,588	3,738	1,150	30.77%	$5,276.94
4	2	2002	32	39.7	2,130	2,888	759	26.27%	$3,480.67
5	1	2002	29	51.8	1,514	1,670	156	9.32%	$713.67
5	31	2002	30	59.6	917	1,245	328	26.33%	$1,503.69
7	1	2002	31	72.2	490	1,286	797	61.94%	$3,654.97
8	1	2002	31	82.1	369	1,286	917	71.30%	$4,207.36
8	30	2002	29	75.5	460	1,203	743	61.76%	$3,409.59
10	1	2002	32	67.0	395	1,328	933	70.26%	$4,279.81
10	30	2002	29	51.1	640	1,726	1,087	62.95%	$4,985.81
11	27	2002	28	37.9	1,203	2,666	1,463	54.88%	$6,711.87
12	31	2002	34	35.6	2,056	3,446	1,390	40.33%	$6,377.24
					16,408	**26,210**	**9,802**	**37.40%**	**$44,972.48**